Practitioner's Docket No. AP9627

CHAPTER II

TRANSMITTAL LETTER TO THE UNITED STATES ELECTED OFFICE (EO/US)

(ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)

PCT/EP00/03785	27/April/2000	30/April/1999
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED

Method for Pressure Modulation of Brake Pressures
TITLE OF INVENTION

Jochen Fuhrer; Markus Bender; Tobias Scheller; Michael Latarnik
APPLICANT(S)

Box PCT
Commissioner for Patents
Washington D.C. 20231
ATTENTION: EO/US

NOTE: To avoid abandonment of the application, the applicant shall furnish to the USPTO, not later than 20 months from the priority date: (1) a copy of the international application, unless it has been previously communicated by the International Bureau or unless it was originally filed in the USPTO; and (2) the basic national fee (see 37 C.F.R. § 1.492(a)). The 30-month time limit may not be extended. 37 C.F.R. § 1.495.

WARNING: *Where the items are those which can be submitted to complete the entry of the international application into the*

CERTIFICATION UNDER 37 C.F.R. 1.10*
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(Express Mail certification is optional.)

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Joyce Krumpe
Signature of person mailing paper

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national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. §1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing - See 37 C.F.R. §1.8.

NOTE: Documents and fees must be clearly identified as a submission to enter the national state under 35 USC 371 otherwise the submission will be considered as being made under 35 USC 111. 37 C.F.R. § 1.494(f).

1. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. 371:

   a. [X] This express request to immediately begin national examination procedures (35 U.S.C. 371(f)).

   b. [X] The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees (37 C.F.R. § 1.492) as indicated below:

2.Fees

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
[ ]*	TOTAL CLAIMS	11 - 20 =		x $ 18.00 =	$
	INDEPENDENT CLAIMS	1 - 3 =		x $ 84.00 =	
	MULTIPLE DEPENDENT CLAIM(S) (if applicable) + $280.00				
BASIC FEE**	[ ] U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO: [ ] and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(2) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 CFR 1.492(a)(4)) ..... $100.00 [ ] and the above requirements are not met (37 CFR 1.492(a)(1)) ..... $710.00 [X] U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO: [ ] has been paid (37 CFR 1.492(a)(2)) ..... $740.00 [ ] has not been paid (37 CFR 1.492(a)(3)) ..... $1040.00 [X] where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 CFR 1.492(a)(5)) $890.00				
	Total of above Calculations				= 890.00
SMALL ENTITY	Reduction by ½ for filing by small entity, if applicable. Affidavit must be filed. (note 37 CFR 1.9, 1.27, 1.28)				-
	Subtotal				890.00
	Total National Fee				$ 890.00
	Fee for recording the enclosed assignment document $40.00 (37 CFR 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".				
TOTAL	Total Fees enclosed				$ 890.00

*See attached Preliminary Amendment Reducing the Number of Claims.

i. [ ] A check in the amount of _____ to cover the above fees is enclosed.

ii. [X] Please charge Account No. 18-0013 in the amount of $ 890.00.

A duplicate copy of this sheet is enclosed.

**WARNING: *"To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date: * * * (2) the basic national fee (see § 1.492(a)). The 30-month time limit may not be extended." 37 C.F.R. § 1.495(b).*

WARNING: *If the translation of the international application and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C.F.R. § 1.495(b)(2). The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1.136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40.*

3. [X] A copy of the International application as filed (35 U.S.C. 371(c)(2)):

NOTE: *Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35-36. See item 14c below.*

a. [X] is transmitted herewith.

b. [ ] is not required, as the application was filed with the United States Receiving Office.

c. [ ] has been transmitted

i. [ ] by the International Bureau.
Date of mailing of the application (from form PCT/IB/308): _____.

ii. [ ] by applicant on _____.
Date

4. [X] A translation of the International application into the English language (35 U.S.C. 371(c)(2)):

a. [X] is transmitted herewith.

b. [ ] is not required as the application was filed in English.

c. [ ] was previously transmitted by applicant on _____.
Date

d. [ ] will follow.

5. [ ] Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. 371(c)(3)):

NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. § 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under section 1.121. In many cases, filing an amendment under section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.

a. [ ] are transmitted herewith.
b. [ ] have been transmitted
   i. [ ] by the International Bureau.
   Date of mailing of the amendment (from form PCT/IB/308): _____.
   ii. [ ] by applicant on _____.
   Date
c. [ ] have not been transmitted as
   i. [ ] applicant chose not to make amendments under PCT Article 19.
   Date of mailing of Search Report (from form PCT/ISA/210): _____.
   ii. [ ] the time limit for the submission of amendments has not yet expired. The amendments or a statement that amendments have not been made will be transmitted before the expiration of the time limit under PCT Rule 46.1.

6. [ ] A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. 371(c)(3)):
   a. [ ] is transmitted herewith.
   b. [ ] is not required as the amendments were made in the English language.
   c. [ ] has not been transmitted for reasons indicated at point 5(c) above.

7. [x] A copy of the international examination report (PCT/IPEA/409)
   [x] is transmitted herewith.
   [ ] is not required as the application was filed with the United States Receiving Office.

8. [x] Annex(es) to the international preliminary examination report
   a. [x] is/are transmitted herewith.
   b. [ ] is/are not required as the application was filed with the United States Receiving Office.

9. [ ] A translation of the annexes to the international preliminary examination report
   a. [ ] is transmitted herewith.
   b. [ ] is not required as the annexes are in the English language.

10. [X] An oath or declaration of the inventor (35 U.S.C. 371(c)(4)) complying with 35 U.S.C. 115
   a. [ ] was previously submitted by applicant on _____.
   Date
   b. [ ] is submitted herewith, and such oath or declaration
      i. [ ] is attached to the application.
      ii. [ ] identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. 1.70.

iii. [X] will follow.

Other document(s) or information included:

11. [x] An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):
    a. [x] is transmitted herewith.
    b. [ ] has been transmitted by the International Bureau.
       Date of mailing (from form PCT/IB/308): _____.
    c. [ ] is not required, as the application was searched by the United States International Searching Authority.
    d. [ ] will be transmitted promptly upon request.
    e. [ ] has been submitted by applicant on _____.
       Date

12. [X] An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98:
    a. [X] is transmitted herewith.
       Also transmitted herewith is/are:
       [X] Form PTO-1449 (PTO/SB/08A and 08B).
       [X] Copies of citations listed.
    b. [ ] will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. 371(c).
    c. [ ] was previously submitted by applicant on _____.
       Date

13. [ ] An assignment document is transmitted herewith for recording.

    A separate [ ] "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or[ ] FORM PTO 1595 is also attached.

    _____
    _____
    _____

14. [X] Additional documents:
    a. [ ] Copy of request (PCT/RO/101)
    b. [x] International Publication No. WO00/66407
       i. [ ] Specification, claims and drawing
       ii. [x] Front page only
    c. [X] Preliminary amendment (37 C.F.R. § 1.121)
    d. [ ] Other

    _____
    _____
    _____

15. [X] The above checked items are being transmitted

a. [X] before 30 months from any claimed priority date.
b. [ ] after 30 months.

16. [ ] Certain requirements under 35 U.S.C. 371 were previously submitted by the applicant on _____, namely:

_____
_____
_____

AUTHORIZATION TO CHARGE ADDITIONAL FEES

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges if extra claims are authorized.*

NOTE: *"A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).*

NOTE: *"Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).*

[X] The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 18-0013.

[X] 37 C.F.R. 1.492(a)(1), (2), (3), and (4) (filing fees)

WARNING: *Because failure to pay the national fee within 30 months without extension (37 C.F.R. § 1.495(b)(2)) results in abandonment of the application, it would be best to always check the above box.*

[X] 37 C.F.R. 1.492(b), (c) and (d) (presentation of extra claims)

NOTE: *Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action.*

[X] 37 C.F.R. 1.17 (application processing fees)
[X] 37 C.F.R. 1.17(a)(1)-(5)(extension fees pursuant to § 1.136(a).
[ ] 37 C.F.R. 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. 1.311(b))

NOTE: *Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of*

allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. § 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

[X] 37 C.F.R. § 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).

SIGNATURE OF PRACTITIONER

Reg. No.: 33,373

Joseph V. Coppola, Sr.
(type or print name of practitioner)

Tel. No.: (248) 594-0650

RADER, FISHMAN & GRAUER PLLC
P.O. Address
39533 Woodward Ave., Suite 140
Bloomfield Hills, MI 48304

CUSTOMER NO.: 010291

AP9627

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Führer et al.

Int'l Application No.: PCT/EP00/03785

Int'l Filing Date: 27/April/2000

Serial No.: Group Art Unit:

Filed: Herewith Examiner:

For: Method for Pressure Modulation of Brake Pressures

Attorney Docket No.: AP9627 Paper No.

Box PCT
Commissioner for Patents
Washington, D.C. 20231
Attn: EO/US

CERTIFICATE OF MAILING/TRANSMISSION (37 CFR 1.8(a))

I hereby certify that this correspondence is, on the date shown below, being:

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Date: 10/30/01

☐ transmitted by facsimile to the Patent and Trademark Office to Examiner _____. at _____ (phone number)

Joyce Krumpe
Signature

Joyce Krumpe
Name

PRELIMINARY AMENDMENT

Dear Sir:

Please amend the application as follows prior to examination on the merits.

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IN THE CLAIMS

Please cancel claims 1-12 and add the following new claims.

13. (New) Method of modulating brake pressure of a vehicle brake circuit, comprising the steps of:

categorizing a vehicle brake circuit into a leading brake circuit portion and a following brake circuit portion,

determining which of said portions has the higher brake pressure demand, and which of said portions has the lower brake pressure demand,

introducing, maintaining, and reducing brake pressure of the following brake circuit portion in dependence on the leading brake circuit portion, such that the brake pressure demand in the following wheel brake circuit is adjusted before adjusting the brake pressure demand in the leading brake circuit.

14. (New) Method as claimed in claim 13, wherein the leading brake circuit is connected to a pressure fluid source by way of opening of a switch valve, and the pressure fluid is introduced into the leading and following brake circuit portion by way of the pressure fluid pump arranged in the vehicle brake circuit, with the brake circuit portion being separated from the pressure fluid source by a separating valve.

15. (New) Method as claimed in claim 13, wherein the leading wheel brake circuit portion is connected to a pressure fluid accumulator and the pressure fluid is introduced into the leading and following wheel brake circuit portion by way of the pressure fluid pump arranged in the vehicle brake circuit, wherein the brake circuit portions are separated from a pressure fluid source by a separating valve.

16. (New) Method as claimed in claim 16, further including the step of controlling the brake pressure demand of the leading and following brake circuit portion by way of an inlet valve of the following brake circuit portion according to the brake pressure demand,

wherein an inlet valve of the leading wheel brake circuit remains open, and the outlet valves of the leading and following wheel brake circuit remains closed.

17. (New) Method as claimed in claim 13, wherein the brake pressure demand of the following wheel brake circuit is changed by delivery out of the leading brake circuit portion, wherein an inlet valve of the following wheel brake circuit portion remains open.

18. (New) Method as claimed in claim 16, wherein when the brake pressure is introduced and is increased compared to the brake pressure demand, the inlet valve of the leading wheel brake circuit is closed in dependence on the brake pressure in the vehicle brake circuit or in dependence on a time constant correlated to a condition variable.

19. (New) Method as claimed in claim 13, wherein the brake pressure in the leading brake circuit portion is discharged into the pressure fluid source by way of the vehicle brake circuit by opening the separating valve.

20. (New) Method as claimed in claim 13, wherein the brake pressure in the following brake circuit portion is discharged through a return line into a pressure fluid accumulator by opening an outlet valve when an inlet valve is closed.

21. (New) Method as claimed in claim 13, wherein the characteristics for the steps introduction, maintaining, and reduction of the brake pressure are predetermined by a pressure controller.

22. (New) Method as claimed in claim 13, wherein the pressure fluid pump is controlled by way of a pulse-width modulated control signal, predetermined by the pressure controller during the introduction of the brake pressure into the leading and following brake circuit portions.

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23. (New) Method as claimed in claim 13, wherein the pressure fluid pump is operated during the steps maintaining and reduction of the brake pressures by way of adjusting the energy supply, or the rotational speed, or the conveying capacity in a predetermined basic (load) condition.

REMARKS

Prior to a formal examination of the above-identified application, acceptance of the new claims and the enclosed substitute specification (under 37 CFR 1.125) is respectfully requested. It is believed that the substitute specification and new claims will facilitate processing of the application in accordance with M.P.E.P. 608.01(q). The substitute specification and new claims are in compliance with 37 CFR 1.52 (a and b) and, while making no substantive changes, are submitted to conform this case to the formal requirements and long-established formal standards of U.S. Patent Office practice, and to provide improved idiom and better grammatical form.

The enclosed substitute specification is presented herein in both marked-up and clean versions.

STATEMENT

The undersigned, an attorney registered to practice before the office, hereby states that the enclosed substitute specification includes the same changes as are indicated in the mark-up copy of the original specification. The substitute specification contains no new subject matter.

Respectfully submitted,

Joseph V. Coppola, Sr.
Registration No. 33,373
Rader, Fishman and Grauer PLLC
39533 Woodward Ave., Suite 140
Bloomfield Hills, Michigan 48304
(248) 594-0650
Attorney for Applicants

R0127364.DOC

SUBSTITUTE SPECIFICATION: CLEAN COPY

AP9627

Method for Pressure Modulation of Brake Pressures

Technical Field

The present invention generally relates to vehicle brake systems, and more particularly relates to a method for the pressure modulation of brake pressures.

Background of The Invention

Beside a primary pressure fluid source for hydraulic fluid (e.g. the brake cylinder/tandem master cylinder), modern vehicle brake systems include one or a plurality of pressure fluid pumps which permit delivering hydraulic fluid that is (additionally) pressurized for defined purposes. For example, these pumps are pressure fluid pumps which are arranged on the valve block and can be operated by way of electric actuation of an electric motor and an eccentric. The purpose of these pressure fluid pumps is the active pressure build-up for defined controlling or regulating purposes when the brake pressure that originates from the main pressure source is not sufficient to reach the control objective. Traction slip control can be named as an example. In the presence of traction slip, the driver generally does not brake at all so that the primary pressure source does not furnish pressure. However, to control traction slip, an active introduction, maintaining, or reduction of brake pressure, in particular on the brakes of the driven wheels, may be desirable so that a device for pressure modulation including pressure build-up must be provided. This device may include the pressure fluid pump mentioned hereinabove.

In a method for pressure modulation of brake pressures for a dual-circuit brake system e.g. with a front-axle/rear-axle split-up on one-axle drive vehicles or with any desired brake force split-up in all-wheel drive vehicles, that is in all dual-circuit brake pressure transmission devices where an active pressure modulation in both wheels with a different brake pressure demand in both wheel brake circuits is provided, this brake pressure modulation has so far

been performed by separately actuating inlet and outlet valves of the respective wheel brake circuit for controlling the traction slip. The pressure fluid source is separated from the pressure-side delivery circuit of the pressure fluid pump to prevent the hydraulic fluid from returning into the pressure fluid source. The above separation is effected by means of a separating valve.

The delivery rate and, thus, indirectly the brake pressure is adjusted this way in each of the two wheel brake circuits of a brake pressure transmission device. However, this suffers from the disadvantage that the valves operate against the pressure of the pressure fluid pump. This produces noises which is audible to the driver and may leave the impression that there is something wrong with the vehicle.

In addition, the prior art pressure modulation by way of the separate actuation of inlet and outlet valves provides a discharge of the brake pressure from both wheel brake circuits via the outlet valves. The pressure fluid flows through the pressure fluid pump and the pressure-limiting valve associated with the separating valve and predefining the pressure level of the brake pressure transmission circuit back into the pressure fluid source. Especially in driving stability control operations and with rear-axle driven vehicles with a high pressure level of the brake pressure transmission circuit, the pressure fluid pump is loaded to a considerable degree because it operates against a high pressure. In addition, noise which is also audible to the driver is produced during overflow of the pressure-limiting valve and during supply by the pressure fluid pump.

A brake system of this type is described in DE 44 27 247 A1. This brake system permits performing a controlled pedal force braking operation and a controlled braking operation by independent force. Pedal force braking refers to a braking operation wherein a brake pressure predetermined by the brake pressure transmission device is built up in the wheel brake circuit by an actuation of the brake cylinder which is intended by the driver, while in a braking operation by independent force, irrespective of pedal application, brake pressure is built up in the wheel brake circuits which can be modulated according to defined control algorithms,

such as in traction slip control or driving stability control operations. In a traction slip control operation, the brake pressure in the brakes of the driven wheels is adjusted so that the engine torque reduced by the brake torque can be transmitted from the tires to the roadway without spinning of the wheels.

The known brake pressure transmission device is comprised of the inlet and outlet valves, the switch valve, the separating valve, the low-pressure accumulators and a return pump. By operation of the inlet and outlet valves, the pressure is introduced, maintained, and reduced in the connected wheel brakes during braking by independent force. The pressure is built up in both wheel brake circuits when the inlet and switch valves are opened and the separating and outlet valves closed. When the pressure of the brake pressure demand is reached, the two inlet valves will be closed, while the return pump is still active. A sufficiently high pressure is built up by the return pump on the inlet side ahead of the inlet valves which prevents a discharge of the pressure fluid by way of the non-return valves bypassing the inlet valve. The switch valve is closed thereafter. Pressure is maintained with the valves closed so that no hydraulic pressure fluid can flow in the wheel brake circuits via switch valve, separating valve, and inlet and outlet valves. For pressure reduction, the outlet valves are opened according to one variation of embodiment so that the pressurized pressure fluid prevailing in the wheel brakes discharges into the low-pressure accumulators from where it is conveyed to the brake cylinder by means of the return pump. The purpose of the low-pressure generator generally is to intermediately store the pressure fluid which is discharged from the wheel brake circuits in the event of a quick pressure reduction, because the return pump, due to its limited conveying capacity, may only supply a defined quantity of pressure fluid per time unit. In another design variation, the inlet valve and the separating valve of a wheel brake circuit are opened so that the pressure fluid of the respective wheel brake circuit flows off through the opened inlet valve directly to the brake cylinder and through said to the pressure fluid source.

An object of the present invention is to provide a method for the pressure modulation of brake pressures which reduces noise emissions and enhances the possibility of braking intervention during braking by independent force.

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The method of pressure modulation of brake pressures with an electric pressure fluid pump in a dual-circuit brake pressure transmission device, with the steps introduction of a brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, maintaining the brake pressure in the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, and discharge of the brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, wherein a split-up of the wheel brake circuits of the one brake pressure transmission circuit into a leading and a following wheel brake circuit with different brake pressure demands is provided, and wherein the leading wheel brake circuit is defined as wheel brake circuit with a higher brake pressure demand, and wherein further the steps introduction, maintaining, and reduction of the brake pressures of the following wheel brake circuit are controlled or regulated by way of the leading wheel brake circuit, the noise emissions in braking by independent force are reduced because the inlet valve of the leading wheel brake circuit remains open also after the brake pressure demand has been reached so that this valve is not required to operate in opposition to the pressure of the pressure fluid pump. Admittedly, the closed inlet valve of the following wheel brake circuit operates in opposition to the pressure of the pressure fluid pump, however, this pressure in the following wheel brake circuit is limited to the differential pressure between the leading and following wheel brake circuit so that the noise emissions during opening of this inlet valve are also reduced. The open inlet valve permits a pedal force braking operation also during pressure modulation.

In an embodiment of the present invention, the wheel brake circuit of the leading wheel is connected to a pressure fluid source (supply reservoir, brake cylinder) by way of opening of a switch valve, and the pressure fluid is introduced into the leading and following wheel brake circuits by way of the pressure fluid pump arranged in the wheel brake circuit, with the brake pressure circuit being separated from the pressure fluid source by a separating valve. This action renders it possible with normally open inlet valves to build up the pressure in both wheel brake circuits corresponding to a brake pressure demand of the wheel brake circuits.

In another embodiment of the present invention, the wheel brake circuit of the leading wheel is connected to a pressure fluid accumulator, with a switch valve closed, and the pressure fluid is introduced into the leading and following wheel brake circuit by way of the pressure fluid pump arranged in the wheel brake circuit, with a brake pressure circuit being separated from a pressure fluid source by a separating valve. Depending on the charging condition of the pressure accumulator (low-pressure accumulator) the pressure fluid required for the pressure build-up for the two wheel brake circuits can be taken from this pressure fluid accumulator and/or the pressure fluid source.

According to the present invention, one inlet valve and one outlet valve is provided in each wheel brake circuit, and the brake pressure demand of the leading and following wheel brake circuits is controlled by way of the inlet valve of the following wheel brake circuit and the pressure fluid supplied by the pressure fluid pump according to the brake pressure demand, with the inlet valve of the leading wheel brake circuit being open, and the outlet valves of the leading and following wheel brake circuit being closed. Due to the division into a leading wheel brake circuit with a higher pressure demand and a following wheel brake circuit with a lower pressure demand, the brake pressure demand of the following wheel brake circuit can always be built up from the leading wheel brake circuit. In this arrangement, the pressure fluid pump for the brake pressure adjustment furnishes only the delivery rate necessary to satisfy the brake pressure demand of the leading wheel brake circuit, there being no need to actuate the inlet valve of the leading wheel brake circuit which is open in its deenergized state.

When the pressure of the following wheel brake circuit must be corrected because e.g. the coefficient of friction of the ground changes during traction slip control, the brake pressure demand of the following wheel brake circuit is changed from the leading wheel brake circuit by opening the inlet valve of the following wheel brake circuit, with the pressure fluid pump being active or passive. When only minor pressure variations must be effected in the following wheel brake circuit, the pressure in the following wheel brake circuit can be changed exclusively out of the leading wheel brake circuit, in the event of a sufficient

difference in pressure between the leading and following wheel brake circuits, without the requirement to correct the pressure in the leading wheel brake circuit towards the brake pressure demand. Advantageously, the brake pressure of the wheel brake circuits is maintained, with the switch valve, separating valve and outlet valve closed, the inlet valve of the leading wheel brake circuit open, and the outlet and inlet valve of the following wheel brake circuit closed. Pedal force braking is possible in this mode of braking by independent force due to the inlet valve of the leading wheel brake circuit being open.

In another variant (special case), the inlet valve of the leading wheel brake circuit is closed in dependence on the brake pressure in the wheel brake circuit or in dependence on a time constant correlated to a condition variable. The inlet valve is closed after a predetermined time after closing of the switch valve. The volume prevailing in the pressure fluid accumulator is then returned into the brake cylinder and the supply reservoir by way of a pressure-limiting valve bypassing the separating valve. This variation is e.g. used only when volume exists in the pressure fluid accumulator due to pressure reduction in the following wheel brake circuit, and in driving situations, such as for example a traction slip control operation at a homogeneous coefficient, in which exceeding of the pressure above the value of the brake pressure demand has considerable negative effects on the wheel behavior.

When, in another embodiment of the present invention, the brake pressure introduced is increased compared to the brake pressure demand, the brake pressure according to a first variation is discharged by way of the brake pressure circuit into the pressure fluid source by opening the separating valve in the leading wheel brake circuit, with the switch and outlet valve closed and the inlet valve open. In a second variation, the brake pressure in the following wheel brake circuit is discharged through a return line into the pressure fluid accumulator by opening the outlet valve when the inlet valve is closed, with the switch valve and/or separating valve in the leading wheel brake circuit being closed or opened in dependence on the steps introduction, or maintaining, or reduction of the brake pressure.

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The controlling or regulating signals for the actuation of the valves according to the method of the present invention, which signals are based on calculated characteristics for the steps introduction, maintaining, and reduction, are predetermined by a pressure controller in which a pressure model is stored and which is connected to the controlling or regulating units for an anti-lock function and/or traction slip control and/or a driving stability function.

For the brake pressure adjustment in the leading and following wheel brake circuits, the pressure fluid pump is controlled by way of gradual quantities predetermined by the pressure controller so that the pump is operated gradually. Operating conditions/delivery rates/rotational speeds of the pressure fluid pump are adjusted by way of the calculated brake pressure demands by way of the electric actuation, for example, by way of a pulse-width modulated signal so that the pressure fluid pump itself is a control element for the adjustment of the brake pressure.

A change in the initial condition of the pump piston, as it occurs upon deactivation of the pressure fluid pump, is avoided because the pressure fluid pump is operated during the steps maintaining and reduction by way of adjusting the energy supply, and/or the rotational speed, and/or the conveying capacity in a predetermined basic (load) condition, preferably with a lowest energy supply, rotational speed, and/or conveying capacity, that means that the pressure fluid pump is actuated so that it will not come to a standstill. This reliably prevents that a delivery volume that is responsive to the pump piston position will lead to an undefined brake pressure adjustment in the wheel brake circuits upon each activation of the pressure fluid pump.

It is, of course, also possible to switch off the return pump when the influence of the delivery volume which is changed due to the pump piston position can be left out of account in the instance the return pump starts to operate.

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Brief Description of The Drawings

Figure 1 is a view of the hydraulic circuit diagram of a brake system according to the present invention.

Figure 2 is a wiring scheme relating to the actuation of the valves, comprising the steps introduction, maintaining, and reduction.

Detailed Description of The Preferred Embodiments

The dual-circuit brake pressure transmission device for vehicles, as illustrated in Figure 1, is comprised of a brake cylinder 1 with a brake force booster 2 which is operated by a brake pedal 3. A supply reservoir 4 is arranged at the brake cylinder 1 which contains a pressure fluid volume and is connected to the working chamber of the brake cylinder 1 in the brake release position. The one brake pressure transmission circuit illustrated includes a brake line 5 that is connected to a working chamber of the brake cylinder 1 and has a separating valve 6 which, in its inactive position, provides an open passage for the brake line 5. The separating valve 6 is usually operated electromagnetically. However, variations where a hydraulic actuation is carried out are also feasible.

The brake line 5 branches into two brake pressure lines 8, 9 which lead to a wheel brake 10, 11, respectively. Each of the brake pressure lines 8, 9 contains an electromagnetically operable inlet valve 12, 19 which is open in its inactive position and can be switched to assume a closed position by energization of the actuating magnet. Connected in parallel to each inlet valve 12, 19 is a non-return valve 13 which opens in the direction of the brake cylinder 1. Connected in parallel to these wheel brake circuits 26, 27 is a so-called return delivery circuit which comprises return lines 15, 32, 33 with a return pump 16. By way of one outlet valve 14, 17, respectively, and return lines 32, 33, the wheel brakes 10, 11 are connected to the return line 15 and, hence, to the suction side of the return pump 16 whose

pressure side is connected to the brake pressure line 8 in an opening point E between the separating valve 6 and the inlet valves 12, 19.

The return pump 16 is designed as a stroke piston pump with a pressure valve (not shown) and a suction valve. At the suction side of the return pump 16, there is a low-pressure accumulator 20 consisting of a housing 21 with a spring 22 and a piston 23.

A biassed non-return valve 34 which opens towards the return pump is inserted into the connection between the low-pressure accumulator 20 and the return pump.

Further, the suction side of the return pump 16 is connected to the brake cylinder 1 by way of an additional line 30 with a low-pressure damper 18 and a switch valve 31. Additionally, the brake force transmission circuit includes a pressure controller 28 with a pressure model 29 for calculating the brake pressure demands in the wheel brake circuits 26, 27. In the pressure controller or in other electronic control units, the wheel brake circuits 26, 27 are evaluated according to the magnitude of the brake pressure demands on the basis of the calculated brake pressure demands in each of the wheel circuits 26, 27. The wheel brake circuits 26 or 27 are divided into a leading and a following wheel brake circuit, respectively, such that the wheel brake circuit, e.g. 26, with the higher brake pressure demand is determined as the leading wheel brake circuit and that the circuit with the lower brake pressure demand is determined as the following wheel brake circuit 27.

In dependence on the steps introduction, maintaining, or reduction of the brake pressures in the wheel brake circuits 26, 27 in a traction slip control operation, controlling or regulating quantities which permit actuating the valves 12, 19, 6, 17, 31 and the return pump are generated based on the brake pressure demands in the pressure controller 28. The following wheel brake circuit 27, is controlled or regulated by way of the leading wheel brake circuit 26. Specifically, hydraulic pressure fluid is introduced upon pressure build-up into the following wheel brake circuit with the lower brake pressure demand in the magnitude of the brake pressure demand from or by way of the leading wheel brake circuit.

As is shown in Figure 2, the pressure build-up in the wheel brake circuits 26, 27 takes place when the switch valve 31 is open and the separating valve 6 closed by way of the actuating signals A and B, with the separating valve 6 being normally open in the initial position and the switch valve 31 being normally closed. In this arrangement, the return pump 16 arranges for the supply of pressure fluid out of the supply reservoir 4 or the low-pressure accumulator 20, by way of the brake cylinder 1, into the wheel brake circuits 26, 27 in which pressure fluid is so introduced in conformity with the calculated brake pressure demand. The pressure fluid is conducted to the wheel brakes 10 and 11 via the opening point E from the brake pressure line 8 of the leading wheel brake circuit 26 and into the brake pressure line 9 of the following wheel brake circuit 27 by way of the inlet valves 12 and 19, respectively. When the calculated value of the brake pressure demand in the following wheel brake circuit 27 is adjusted, the inlet valve 19 is closed by means of a switching pulse. The pressure fluid is introduced by the gradually actuated motor of the return pump in the leading wheel brake circuit 26 until the brake pressure demand is reached. Subsequently, the inlet valve 12 remains open, and the switch valve 31 will be closed. Separating valve 6 remains closed. A constant pressure C develops.

The brake pressure in the wheel brake circuits 26, 27 is maintained preferably when the inlet valve 12 is open. The return pump 16 is operated in a basic load condition, that means with lowest conveying capacity, and/or energy supply, and/or rotational speed so that the pump piston is just about moved by the eccentric. This operation of the return pump 16 in the basic load condition is preferably controlled by way of the pulse-width modulated actuation of the pump motor when no pressure fluid volume is stored in the low-pressure accumulator 20. In a special case which is not desirable, an excess pressure that is due to the replenishment supply of the return pump out of the low-pressure accumulator 20 or damper 18 during maintaining the brake pressure in the leading wheel brake circuit 26 is effectively prevented by closing of the inlet valve 12. Closing of the inlet valve 12 is effected by a time-responsive switching pulse after closing of the switch valve 31 in driving situations, such as a traction slip control operation on a homogeneous coefficient of friction, in which exceeding of the pressure

beyond the value of the brake pressure demand has considerable negative effects on the wheel behavior. Alternatively, the brake pressure as well can be sensed or calculated, and the inlet valve 12 can be closed in response to the brake pressure. The contents of the low-pressure accumulator 20 and/or damper 18 is returned into the brake cylinder 1 and the supply reservoir 4 by way of the pressure-relief valve 25.

The pressure discharge F of the leading wheel brake circuit 26 is effected by opening the separating valve 6 so that pressure fluid flows through the open inlet valve 12, the separating valve 6, and the brake cylinder 1 into the supply reservoir 4. The separating valve 6 is closed by the pressure controller 28 by means of switching pulses D after each pressure reduction. In the following wheel brake circuit 27, pressure fluid is returned out of the wheel brake 11 into the low-pressure accumulator 20 when the outlet valve 17 is open and the inlet valve 19 closed. The low-pressure accumulator 20 assumes a buffer function in this operation.

A correction of the brake pressure demand of the following wheel brake circuit 27 towards a brake pressure increase is carried out by opening the inlet valve 19 out of the leading wheel brake circuit whose brake pressure demand is also corrected in dependence on predetermined control thresholds or wherein the reduced brake pressure is tolerated.

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Method for the Pressure Modulation of Brake Pressures

Abstract of The Disclosure

The present invention relates to a method for the pressure modulation of brake pressures with an electric pressure fluid pump in a dual-circuit brake pressure transmission device, with the steps introduction of a brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, maintaining the brake pressure in the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, and discharge of the brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit. To reduce noise emissions and to enhance the possibilities of braking intervention by the driver during a braking operation by independent force, a split-up of the wheel brake circuits of the one brake pressure transmission circuit into a leading and a following wheel brake circuit with different brake pressure demands is provided, wherein the leading wheel brake circuit is defined as wheel brake circuit with a higher brake pressure demand, and wherein further the steps introduction, maintaining, and reduction of the brake pressure of the following wheel brake circuit are controlled or regulated by way of the leading wheel brake circuit.

SUBSTITUTE SPECIFICATION: MARKED UP COPY

[PC 9627]

Method for Pressure Modulation of Brake Pressures

Technical Field

The present invention generally relates to vehicle brake systems, and more particularly relates to a method for the pressure modulation of brake pressures [according to the preamble of claim 1].

Background of The Invention

Beside a primary pressure fluid source for hydraulic fluid (e.g. the brake cylinder/tandem master cylinder), modern vehicle brake systems include one or a plurality of pressure fluid pumps which permit delivering hydraulic fluid that is (additionally) pressurized for defined purposes. For example, these pumps are pressure fluid pumps which are arranged on the valve block and can be operated by way of electric actuation of an electric motor and an eccentric. The purpose of these pressure fluid pumps is the active pressure build-up for defined controlling or regulating purposes when the brake pressure that originates from the main pressure source is not sufficient to reach the control objective. Traction slip control can be named as an example. In the presence of traction slip, the driver generally does not brake at all so that the primary pressure source does not furnish pressure. However, to control traction slip, an active introduction, maintaining, or reduction of brake pressure, in particular on the brakes of the driven wheels, may be desirable so that a device for pressure modulation including pressure build-up must be provided. This device may include the pressure fluid pump mentioned hereinabove.

In a method for pressure modulation of brake pressures for a dual-circuit brake system e.g. with a front-axle/rear-axle split-up on one-axle drive vehicles or with any desired brake force split-up in all-wheel drive vehicles, that is in all dual-circuit brake pressure transmission devices where an active pressure modulation in both wheels with a different brake pressure demand in both wheel brake circuits is provided, this brake pressure modulation has so far

been performed by separately actuating inlet and outlet valves of the respective wheel brake circuit for controlling the traction slip. The pressure fluid source is separated from the pressure-side delivery circuit of the pressure fluid pump to prevent the hydraulic fluid from returning into the pressure fluid source. The above separation is effected by means of a separating valve.

The delivery rate and, thus, indirectly the brake pressure is adjusted this way in each of the two wheel brake circuits of a brake pressure transmission device. However, this suffers from the disadvantage that the valves operate against the pressure of the pressure fluid pump. This produces noises which[, exactly as the ABS intervention, become audible] is audible to the driver and may leave the impression that there is something wrong with the vehicle [an alarming driving situation although this does not automatically have to be the case (for example, in traction slip control or in a regular braking operation)].

In addition, the prior art pressure modulation by way of the separate actuation of inlet and outlet valves provides a discharge of the brake pressure from both wheel brake circuits via the outlet valves. The pressure fluid flows through the pressure fluid pump and the pressure-limiting valve associated with the separating valve and predefining the pressure level of the brake pressure transmission circuit back into the pressure fluid source. Especially in driving stability control operations and with rear-axle driven vehicles with a high pressure level of the brake pressure transmission circuit, the pressure fluid pump is loaded to a considerable degree because it operates against a high pressure. In addition, noise which is also audible to the driver is produced during overflow of the pressure-limiting valve and during supply by the pressure fluid pump.

A brake system of this type is described in DE 44 27 247 A1. This brake system permits performing a controlled pedal force braking operation and a controlled braking operation by independent force. Pedal force braking refers to a braking operation wherein a brake pressure predetermined by the brake pressure transmission device is built up in the wheel brake circuit by an actuation of the brake cylinder which is intended by the driver, while in a braking

operation by independent force, irrespective of pedal application, brake pressure is built up in the wheel brake circuits which can be modulated according to defined control algorithms, such as in traction slip control or driving stability control operations. In a traction slip control operation, the brake pressure in the brakes of the driven wheels is adjusted so that the engine torque reduced by the brake torque can be transmitted from the tires to the roadway without spinning of the wheels.

The known brake pressure transmission device is comprised of the inlet and outlet valves, the switch valve, the separating valve, the low-pressure accumulators and a return pump. By operation of the inlet and outlet valves, the pressure is introduced, maintained, and reduced in the connected wheel brakes during braking by independent force. The pressure is built up in both wheel brake circuits when the inlet and switch valves are opened and the separating and outlet valves closed. When the pressure of the brake pressure demand is reached, the two inlet valves will be closed, while the return pump is still active. A sufficiently high pressure is built up by the return pump on the inlet side ahead of the inlet valves which prevents a discharge of the pressure fluid by way of the non-return valves bypassing the inlet valve. The switch valve is closed thereafter. Pressure is maintained with the valves closed so that no hydraulic pressure fluid can flow in the wheel brake circuits via switch valve, separating valve, and inlet and outlet valves. For pressure reduction, the outlet valves are opened according to one variation of embodiment so that the pressurized pressure fluid prevailing in the wheel brakes discharges into the low-pressure accumulators from where it is conveyed to the brake cylinder by means of the return pump. The purpose of the low-pressure generator generally is to intermediately store the pressure fluid which is discharged from the wheel brake circuits in the event of a quick pressure reduction, because the return pump, due to its limited conveying capacity, may only supply a defined quantity of pressure fluid per time unit. In another design variation, the inlet valve and the separating valve of a wheel brake circuit are opened so that the pressure fluid of the respective wheel brake circuit flows off through the opened inlet valve directly to the brake cylinder and through said to the pressure fluid source.

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An object of the present invention is to provide a method for the pressure modulation of brake pressures which reduces noise emissions and enhances the possibility of braking intervention during braking by independent force.

[According to the present invention, this object is achieved by the features of claim 1.

Favorable improvements of the present invention are disclosed in the subclaims.]

The method of pressure modulation of brake pressures with an electric pressure fluid pump in a dual-circuit brake pressure transmission device, with the steps introduction of a brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, maintaining the brake pressure in the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, and discharge of the brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, wherein a split-up of the wheel brake circuits of the one brake pressure transmission circuit into a leading and a following wheel brake circuit with different brake pressure demands is provided, and wherein the leading wheel brake circuit is defined as wheel brake circuit with a higher brake pressure demand, and wherein further the steps introduction, maintaining, and reduction of the brake pressures of the following wheel brake circuit are controlled or regulated by way of the leading wheel brake circuit, the noise emissions in braking by independent force are reduced because the inlet valve of the leading wheel brake circuit remains open also after the brake pressure demand has been reached so that this valve is not required to operate in opposition to the pressure of the pressure fluid pump. Admittedly, the closed inlet valve of the following wheel brake circuit operates in opposition to the pressure of the pressure fluid pump, however, this pressure in the following wheel brake circuit is limited to the differential pressure between the leading and following wheel brake circuit so that the noise emissions during opening of this inlet valve are also reduced. The open inlet valve permits a pedal force braking operation also during pressure modulation.

In an embodiment of the present invention, the wheel brake circuit of the leading wheel is connected to a pressure fluid source (supply reservoir, brake cylinder) by way of opening of a switch valve, and the pressure fluid is introduced into the leading and following wheel brake circuits by way of the pressure fluid pump arranged in the wheel brake circuit, with the brake pressure circuit being separated from the pressure fluid source by a separating valve. This action renders it possible with normally open inlet valves to build up the pressure in both wheel brake circuits corresponding to a brake pressure demand of the wheel brake circuits.

In another embodiment of the present invention, the wheel brake circuit of the leading wheel is connected to a pressure fluid accumulator, with a switch valve closed, and the pressure fluid is introduced into the leading and following wheel brake circuit by way of the pressure fluid pump arranged in the wheel brake circuit, with a brake pressure circuit being separated from a pressure fluid source by a separating valve. Depending on the charging condition of the pressure accumulator (low-pressure accumulator) the pressure fluid required for the pressure build-up for the two wheel brake circuits can be taken from this pressure fluid accumulator and/or the pressure fluid source.

According to the present invention, one inlet valve and one outlet valve is provided in each wheel brake circuit, and the brake pressure demand of the leading and following wheel brake circuits is controlled by way of the inlet valve of the following wheel brake circuit and the pressure fluid supplied by the pressure fluid pump according to the brake pressure demand, with the inlet valve of the leading wheel brake circuit being open, and the outlet valves of the leading and following wheel brake circuit being closed. Due to the division into a leading wheel brake circuit with a higher pressure demand and a following wheel brake circuit with a lower pressure demand, the brake pressure demand of the following wheel brake circuit can always be built up from the leading wheel brake circuit. In this arrangement, the pressure fluid pump for the brake pressure adjustment furnishes only the delivery rate necessary to satisfy the brake pressure demand of the leading wheel brake circuit, there being no need to actuate the inlet valve of the leading wheel brake circuit which is open in its deenergized state.

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When the pressure of the following wheel brake circuit must be corrected because e.g. the coefficient of friction of the ground changes during traction slip control, the brake pressure demand of the following wheel brake circuit is changed from the leading wheel brake circuit by opening the inlet valve of the following wheel brake circuit, with the pressure fluid pump being active or passive. When only minor pressure variations must be effected in the following wheel brake circuit, the pressure in the following wheel brake circuit can be changed exclusively out of the leading wheel brake circuit, in the event of a sufficient difference in pressure between the leading and following wheel brake circuits, without the requirement to correct the pressure in the leading wheel brake circuit towards the brake pressure demand. Advantageously, the brake pressure of the wheel brake circuits is maintained, with the switch valve, separating valve and outlet valve closed, the inlet valve of the leading wheel brake circuit open, and the outlet and inlet valve of the following wheel brake circuit closed. Pedal force braking is possible in this mode of braking by independent force due to the inlet valve of the leading wheel brake circuit being open.

In another variant (special case), the inlet valve of the leading wheel brake circuit is closed in dependence on the brake pressure in the wheel brake circuit or in dependence on a time constant correlated to a condition variable. The inlet valve is closed after a predetermined time after closing of the switch valve. The volume prevailing in the pressure fluid accumulator is then returned into the brake cylinder and the supply reservoir by way of a pressure-limiting valve bypassing the separating valve. This variation is e.g. used only when volume exists in the pressure fluid accumulator due to pressure reduction in the following wheel brake circuit, and in driving situations, such as for example a traction slip control operation at a homogeneous coefficient, in which exceeding of the pressure above the value of the brake pressure demand has considerable negative effects on the wheel behavior.

When, in another embodiment of the present invention, the brake pressure introduced is increased compared to the brake pressure demand, the brake pressure according to a first variation is discharged by way of the brake pressure circuit into the pressure fluid source by

opening the separating valve in the leading wheel brake circuit, with the switch and outlet valve closed and the inlet valve open. In a second variation, the brake pressure in the following wheel brake circuit is discharged through a return line into the pressure fluid accumulator by opening the outlet valve when the inlet valve is closed, with the switch valve and/or separating valve in the leading wheel brake circuit being closed or opened in dependence on the steps introduction, or maintaining, or reduction of the brake pressure.

The controlling or regulating signals for the actuation of the valves according to the method of the present invention, which signals are based on calculated characteristics for the steps introduction, maintaining, and reduction, are predetermined by a pressure controller in which a pressure model is stored and which is connected to the controlling or regulating units for an anti-lock function and/or traction slip control and/or a driving stability function.

For the brake pressure adjustment in the leading and following wheel brake circuits, the pressure fluid pump is controlled by way of gradual quantities predetermined by the pressure controller so that the pump is operated gradually. Operating conditions/delivery rates/rotational speeds of the pressure fluid pump are adjusted by way of the calculated brake pressure demands by way of the electric actuation, for example, by way of a pulse-width modulated signal so that the pressure fluid pump itself is a control element for the adjustment of the brake pressure.

A change in the initial condition of the pump piston, as it occurs upon deactivation of the pressure fluid pump, is avoided because the pressure fluid pump is operated during the steps maintaining and reduction by way of adjusting the energy supply, and/or the rotational speed, and/or the conveying capacity in a predetermined basic (load) condition, preferably with a lowest energy supply, rotational speed, and/or conveying capacity, that means that the pressure fluid pump is actuated so that it will not come to a standstill. This reliably prevents that a delivery volume that is responsive to the pump piston position will lead to an undefined brake pressure adjustment in the wheel brake circuits upon each activation of the pressure fluid pump.

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It is, of course, also possible to switch off the return pump when the influence of the delivery volume which is changed due to the pump piston position can be left out of account in the instance the return pump starts to operate.

[One embodiment of the present invention is illustrated in the drawings and will be described in detail in the following.

In the drawings,]

Brief Description of The Drawings

Figure 1 is a view of the hydraulic circuit diagram of a brake system according to the present invention.

Figure 2 is a wiring scheme relating to the actuation of the valves, comprising the steps introduction, maintaining, and reduction.

Detailed Description of The Preferred Embodiments

The dual-circuit brake pressure transmission device for vehicles, as illustrated in Figure 1, is comprised of a brake cylinder 1 with a brake force booster 2 which is operated by a brake pedal 3. A supply reservoir 4 is arranged at the brake cylinder 1 which contains a pressure fluid volume and is connected to the working chamber of the brake cylinder 1 in the brake release position. The one brake pressure transmission circuit illustrated includes a brake line 5 that is connected to a working chamber of the brake cylinder 1 and has a separating valve 6 which, in its inactive position, provides an open passage for the brake line 5. The separating valve 6 is usually operated electromagnetically. However, variations where a hydraulic actuation is carried out are also feasible.

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The brake line 5 branches into two brake pressure lines 8, 9 which lead to a wheel brake 10, 11, respectively. Each of the brake pressure lines 8, 9 contains an electromagnetically operable inlet valve 12, 19 which is open in its inactive position and can be switched to assume a closed position by energization of the actuating magnet. Connected in parallel to each inlet valve 12, 19 is a non-return valve 13 which opens in the direction of the brake cylinder 1. Connected in parallel to these wheel brake circuits 26, 27 is a so-called return delivery circuit which comprises return lines 15, 32, 33 with a return pump 16. By way of one outlet valve 14, 17, respectively, and return lines 32, 33, the wheel brakes 10, 11 are connected to the return line 15 and, hence, to the suction side of the return pump 16 whose pressure side is connected to the brake pressure line 8 in an opening point E between the separating valve 6 and the inlet valves 12, 19.

The return pump 16 is designed as a stroke piston pump with a pressure valve (not shown) and a suction valve. At the suction side of the return pump 16, there is a low-pressure accumulator 20 consisting of a housing 21 with a spring 22 and a piston 23.

A biassed non-return valve 34 which opens towards the return pump is inserted into the connection between the low-pressure accumulator 20 and the return pump.

Further, the suction side of the return pump 16 is connected to the brake cylinder 1 by way of an additional line 30 with a low-pressure damper 18 and a switch valve 31. [Besides] Additionally, the brake force transmission circuit includes a pressure controller 28 with a pressure model [19] 29 for calculating the brake pressure demands in the wheel brake circuits 26, 27. In the pressure controller or in other electronic control units, the wheel brake circuits 26, 27 are evaluated according to the magnitude of the brake pressure demands on the basis of the calculated brake pressure demands in each of the wheel circuits 26, 27. The wheel brake circuits 26 or 27 are divided into a leading [or] and a following wheel brake circuit, respectively, [to] such [an end] that the wheel brake circuit, e.g. 26, with the higher brake pressure demand is determined as the leading wheel brake circuit and that the circuit with the lower brake pressure demand is determined as the following wheel brake circuit 27.

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In dependence on the steps introduction, maintaining, or reduction of the brake pressures in the wheel brake circuits 26, 27 in a traction slip control operation, controlling or regulating quantities which permit actuating the valves 12, 19, 6, 17, 31 and the return pump are generated based on the brake pressure demands in the pressure controller 28. The following wheel brake circuit 27, [26 or 27] is controlled or regulated by way of the leading wheel brake circuit 26 [or 27, that means] . Specifically, hydraulic pressure fluid is introduced upon pressure build-up into the following wheel brake circuit with the lower brake pressure demand in the magnitude of the brake pressure demand from or by way of the leading wheel brake circuit.

As is shown in Figure 2, the pressure build-up in the wheel brake circuits 26, 27 takes place when the switch valve 31 is open and the separating valve 6 closed by way of the actuating signals A and B, with the separating valve 6 being normally open in the initial position and the switch valve 31 being normally closed. In this arrangement, the return pump 16 arranges for the supply of pressure fluid out of the supply reservoir 4 or the low-pressure accumulator 20, by way of the brake cylinder 1, into the wheel brake circuits 26, 27 in which pressure fluid is so introduced in conformity with the calculated brake pressure demand. The pressure fluid is conducted to the wheel brakes 10 and 11 via the opening point E from the brake pressure line 8 of the [e.g.] leading wheel brake circuit 26 and into the brake pressure line 9 of the following wheel brake circuit 27 by way of the inlet valves 12 and 19, respectively. When the calculated value of the brake pressure demand in the following wheel brake circuit 27 is adjusted, the inlet valve 19 is closed by means of a switching pulse. The pressure fluid is introduced by the gradually actuated motor of the return pump in the leading wheel brake circuit 26 until the brake pressure demand is reached. Subsequently, the inlet valve 12 remains open, and the switch valve 31 will be closed. Separating valve 6 remains closed. A constant pressure C develops.

The brake pressure in the wheel brake circuits 26, 27 is maintained preferably when the inlet valve 12 is open. The return pump 16 is operated in a basic load condition, that means with

lowest conveying capacity, and/or energy supply, and/or rotational speed so that the pump piston is just about moved by the eccentric. This operation of the return pump 16 in the basic load condition is preferably controlled by way of the pulse-width modulated actuation of the pump motor when no pressure fluid volume is stored in the low-pressure accumulator 20. In a special case which is not desirable, an excess pressure that is due to the replenishment supply of the return pump out of the low-pressure accumulator 20 or damper 18 during maintaining the brake pressure in the leading wheel brake circuit 26 is effectively prevented by closing of the inlet valve 12. Closing of the inlet valve 12 is effected by a time-responsive switching pulse after closing of the switch valve 31 in driving situations, such as a traction slip control operation on a homogeneous coefficient of friction, in which exceeding of the pressure beyond the value of the brake pressure demand has considerable negative effects on the wheel behavior. Alternatively, the brake pressure as well can be sensed or calculated, and the inlet valve 12 can be closed in response to the brake pressure. The contents of the low-pressure accumulator 20 and/or damper 18 is returned into the brake cylinder 1 and the supply reservoir 4 by way of the pressure-relief valve 25.

The pressure discharge F of the leading wheel brake circuit 26 is effected by opening the separating valve 6 so that pressure fluid flows through the open inlet valve 12, the separating valve 6, and the brake cylinder 1 into the supply reservoir 4. The separating valve 6 is closed by the pressure controller 28 by means of switching pulses D after each pressure reduction. In the following wheel brake circuit 27, pressure fluid is returned out of the wheel brake 11 into the low-pressure accumulator 20 when the outlet valve 17 is open and the inlet valve 19 closed. The low-pressure accumulator 20 assumes a buffer function in this operation.

A correction of the brake pressure demand of the following wheel brake circuit 27 towards a brake pressure increase is carried out by opening the inlet valve 19 out of the leading wheel brake circuit whose brake pressure demand is also corrected in dependence on predetermined control thresholds or wherein the reduced brake pressure is tolerated.

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[Abstract:]

Method for the Pressure Modulation of Brake Pressures

Abstract of The Disclosure

The present invention relates to a method for the pressure modulation of brake pressures with an electric pressure fluid pump in a dual-circuit brake pressure transmission device, with the steps introduction of a brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, maintaining the brake pressure in the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, and discharge of the brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit. To reduce noise emissions and to enhance the possibilities of braking intervention by the driver during a braking operation by independent force, a split-up of the wheel brake circuits [(26, 27)] of the one brake pressure transmission circuit into a leading and a following wheel brake circuit with different brake pressure demands is provided, wherein the leading wheel brake circuit [(26 or 27)] is defined as wheel brake circuit with a higher brake pressure demand, and wherein further the steps introduction, maintaining, and reduction of the brake pressure of the following wheel brake circuit are controlled or regulated by way of the leading wheel brake circuit.

[(Figure 1)]

5/PRTS

Method for Pressure Modulation of Brake Pressures

The present invention relates to a method for the pressure modulation of brake pressures according to the preamble of claim 1.

Beside a primary pressure fluid source for hydraulic fluid (e.g. the brake cylinder/tandem master cylinder), modern vehicle brake systems include one or a plurality of pressure fluid pumps which permit delivering hydraulic fluid that is (additionally) pressurized for defined purposes. For example, these pumps are pressure fluid pumps which are arranged on the valve block and can be operated by way of electric actuation of an electric motor and an eccentric. The purpose of these pressure fluid pumps is the active pressure build-up for defined controlling or regulating purposes when the brake pressure that originates from the main pressure source is not sufficient to reach the control objective. Traction slip control can be named as an example. In the presence of traction slip, the driver generally does not brake at all so that the primary pressure source does not furnish pressure. However, to control traction slip, an active introduction, maintaining, or reduction of brake pressure, in particular on the brakes of the driven wheels, may be desirable so that a device for pressure modulation including pressure build-up must be provided. This device may include the pressure fluid pump mentioned hereinabove.

In a method for pressure modulation of brake pressures for a dual-circuit brake system e.g. with a front-axle/rear-axle split-up on one-axle drive vehicles or with any desired brake force split-up in all-wheel drive vehicles, that is in all

dual-circuit brake pressure transmission devices where an active pressure modulation in both wheels with a different brake pressure demand in both wheel brake circuits is provided, this brake pressure modulation has so far been performed by separately actuating inlet and outlet valves of the respective wheel brake circuit for controlling the traction slip. The pressure fluid source is separated from the pressure-side delivery circuit of the pressure fluid pump to prevent the hydraulic fluid from returning into the pressure fluid source. The above separation is effected by means of a separating valve.

The delivery rate and, thus, indirectly the brake pressure is adjusted this way in each of the two wheel brake circuits of a brake pressure transmission device. However, this suffers from the disadvantage that the valves operate against the pressure of the pressure fluid pump. This produces noises which, exactly as the ABS intervention, become audible to the driver and leave the impression that there is an alarming driving situation although this does not automatically have to be the case (for example, in traction slip control or in a regular braking operation).

In addition, the prior art pressure modulation by way of the separate actuation of inlet and outlet valves provides a discharge of the brake pressure from both wheel brake circuits via the outlet valves. The pressure fluid flows through the pressure fluid pump and the pressure-limiting valve associated with the separating valve and predefining the pressure level of the brake pressure transmission circuit back into the pressure fluid source. Especially in driving stability control operations and with rear-axle driven vehicles with a high pressure level of the brake pressure transmission circuit, the pressure fluid pump is loaded to a considerable degree because it operates against a high pressure. In addition, noise which

is also audible to the driver is produced during overflow of the pressure-limiting valve and during supply by the pressure fluid pump.

A brake system of this type is described in DE 44 27 247 A1. This brake system permits performing a controlled pedal force braking operation and a controlled braking operation by independent force. Pedal force braking refers to a braking operation wherein a brake pressure predetermined by the brake pressure transmission device is built up in the wheel brake circuit by an actuation of the brake cylinder which is intended by the driver, while in a braking operation by independent force, irrespective of pedal application, brake pressure is built up in the wheel brake circuits which can be modulated according to defined control algorithms, such as in traction slip control or driving stability control operations. In a traction slip control operation, the brake pressure in the brakes of the driven wheels is adjusted so that the engine torque reduced by the brake torque can be transmitted from the tires to the roadway without spinning of the wheels.

The known brake pressure transmission device is comprised of the inlet and outlet valves, the switch valve, the separating valve, the low-pressure accumulators and a return pump. By operation of the inlet and outlet valves, the pressure is introduced, maintained, and reduced in the connected wheel brakes during braking by independent force. The pressure is built up in both wheel brake circuits when the inlet and switch valves are opened and the separating and outlet valves closed. When the pressure of the brake pressure demand is reached, the two inlet valves will be closed, while the return pump is still active. A sufficiently high pressure is built up by the return pump on the inlet side ahead of the inlet valves which prevents a discharge of the pressure fluid by way of the non-return valves bypassing the inlet valve. The switch valve is closed

thereafter. Pressure is maintained with the valves closed so that no hydraulic pressure fluid can flow in the wheel brake circuits via switch valve, separating valve, and inlet and outlet valves. For pressure reduction, the outlet valves are opened according to one variation of embodiment so that the pressurized pressure fluid prevailing in the wheel brakes discharges into the low-pressure accumulators from where it is conveyed to the brake cylinder by means of the return pump. The purpose of the low-pressure generator generally is to intermediately store the pressure fluid which is discharged from the wheel brake circuits in the event of a quick pressure reduction, because the return pump, due to its limited conveying capacity, may only supply a defined quantity of pressure fluid per time unit. In another design variation, the inlet valve and the separating valve of a wheel brake circuit are opened so that the pressure fluid of the respective wheel brake circuit flows off through the opened inlet valve directly to the brake cylinder and through said to the pressure fluid source.

An object of the present invention is to provide a method for the pressure modulation of brake pressures which reduces noise emissions and enhances the possibility of braking intervention during braking by independent force.

According to the present invention, this object is achieved by the features of claim 1.

Favorable improvements of the present invention are disclosed in the subclaims.

The method of pressure modulation of brake pressures with an electric pressure fluid pump in a dual-circuit brake pressure transmission device, with the steps introduction of a brake pressure into the one and/or the other wheel brake circuit of

the one brake pressure transmission circuit, maintaining the brake pressure in the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, and discharge of the brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, wherein a split-up of the wheel brake circuits of the one brake pressure transmission circuit into a leading and a following wheel brake circuit with different brake pressure demands is provided, and wherein the leading wheel brake circuit is defined as wheel brake circuit with a higher brake pressure demand, and wherein further the steps introduction, maintaining, and reduction of the brake pressures of the following wheel brake circuit are controlled or regulated by way of the leading wheel brake circuit, the noise emissions in braking by independent force are reduced because the inlet valve of the leading wheel brake circuit remains open also after the brake pressure demand has been reached so that this valve is not required to operate in opposition to the pressure of the pressure fluid pump. Admittedly, the closed inlet valve of the following wheel brake circuit operates in opposition to the pressure of the pressure fluid pump, however, this pressure in the following wheel brake circuit is limited to the differential pressure between the leading and following wheel brake circuit so that the noise emissions during opening of this inlet valve are also reduced. The open inlet valve permits a pedal force braking operation also during pressure modulation.

In an embodiment of the present invention, the wheel brake circuit of the leading wheel is connected to a pressure fluid source (supply reservoir, brake cylinder) by way of opening of a switch valve, and the pressure fluid is introduced into the leading and following wheel brake circuits by way of the pressure fluid pump arranged in the wheel brake circuit, with the brake pressure circuit being separated from the pressure

fluid source by a separating valve. This action renders it possible with normally open inlet valves to build up the pressure in both wheel brake circuits corresponding to a brake pressure demand of the wheel brake circuits.

In another embodiment of the present invention, the wheel brake circuit of the leading wheel is connected to a pressure fluid accumulator, with a switch valve closed, and the pressure fluid is introduced into the leading and following wheel brake circuit by way of the pressure fluid pump arranged in the wheel brake circuit, with a brake pressure circuit being separated from a pressure fluid source by a separating valve. Depending on the charging condition of the pressure accumulator (low-pressure accumulator) the pressure fluid required for the pressure build-up for the two wheel brake circuits can be taken from this pressure fluid accumulator and/or the pressure fluid source.

According to the present invention, one inlet valve and one outlet valve is provided in each wheel brake circuit, and the brake pressure demand of the leading and following wheel brake circuits is controlled by way of the inlet valve of the following wheel brake circuit and the pressure fluid supplied by the pressure fluid pump according to the brake pressure demand, with the inlet valve of the leading wheel brake circuit being open, and the outlet valves of the leading and following wheel brake circuit being closed. Due to the division into a leading wheel brake circuit with a higher pressure demand and a following wheel brake circuit with a lower pressure demand, the brake pressure demand of the following wheel brake circuit can always be built up from the leading wheel brake circuit. In this arrangement, the pressure fluid pump for the brake pressure adjustment furnishes only the delivery rate necessary to satisfy the brake pressure demand of the leading wheel brake circuit, there being no need to actuate the inlet valve of the

leading wheel brake circuit which is open in its deenergized state.

When the pressure of the following wheel brake circuit must be corrected because e.g. the coefficient of friction of the ground changes during traction slip control, the brake pressure demand of the following wheel brake circuit is changed from the leading wheel brake circuit by opening the inlet valve of the following wheel brake circuit, with the pressure fluid pump being active or passive. When only minor pressure variations must be effected in the following wheel brake circuit, the pressure in the following wheel brake circuit can be changed exclusively out of the leading wheel brake circuit, in the event of a sufficient difference in pressure between the leading and following wheel brake circuits, without the requirement to correct the pressure in the leading wheel brake circuit towards the brake pressure demand. Advantageously, the brake pressure of the wheel brake circuits is maintained, with the switch valve, separating valve and outlet valve closed, the inlet valve of the leading wheel brake circuit open, and the outlet and inlet valve of the following wheel brake circuit closed. Pedal force braking is possible in this mode of braking by independent force due to the inlet valve of the leading wheel brake circuit being open.

In another variant (special case), the inlet valve of the leading wheel brake circuit is closed in dependence on the brake pressure in the wheel brake circuit or in dependence on a time constant correlated to a condition variable. The inlet valve is closed after a predetermined time after closing of the switch valve. The volume prevailing in the pressure fluid accumulator is then returned into the brake cylinder and the supply reservoir by way of a pressure-limiting valve bypassing the separating valve. This variation is e.g. used only when volume exists in the pressure fluid accumulator due to pressure

reduction in the following wheel brake circuit, and in driving situations, such as for example a traction slip control operation at a homogeneous coefficient, in which exceeding of the pressure above the value of the brake pressure demand has considerable negative effects on the wheel behavior.

When, in another embodiment of the present invention, the brake pressure introduced is increased compared to the brake pressure demand, the brake pressure according to a first variation is discharged by way of the brake pressure circuit into the pressure fluid source by opening the separating valve in the leading wheel brake circuit, with the switch and outlet valve closed and the inlet valve open. In a second variation, the brake pressure in the following wheel brake circuit is discharged through a return line into the pressure fluid accumulator by opening the outlet valve when the inlet valve is closed, with the switch valve and/or separating valve in the leading wheel brake circuit being closed or opened in dependence on the steps introduction, or maintaining, or reduction of the brake pressure.

The controlling or regulating signals for the actuation of the valves according to the method of the present invention, which signals are based on calculated characteristics for the steps introduction, maintaining, and reduction, are predetermined by a pressure controller in which a pressure model is stored and which is connected to the controlling or regulating units for an anti-lock function and/or traction slip control and/or a driving stability function.

For the brake pressure adjustment in the leading and following wheel brake circuits, the pressure fluid pump is controlled by way of gradual quantities predetermined by the pressure controller so that the pump is operated gradually. Operating conditions/delivery rates/rotational speeds of the pressure

fluid pump are adjusted by way of the calculated brake pressure demands by way of the electric actuation, for example, by way of a pulse-width modulated signal so that the pressure fluid pump itself is a control element for the adjustment of the brake pressure.

A change in the initial condition of the pump piston, as it occurs upon deactivation of the pressure fluid pump, is avoided because the pressure fluid pump is operated during the steps maintaining and reduction by way of adjusting the energy supply, and/or the rotational speed, and/or the conveying capacity in a predetermined basic (load) condition, preferably with a lowest energy supply, rotational speed, and/or conveying capacity, that means that the pressure fluid pump is actuated so that it will not come to a standstill. This reliably prevents that a delivery volume that is responsive to the pump piston position will lead to an undefined brake pressure adjustment in the wheel brake circuits upon each activation of the pressure fluid pump.

It is, of course, also possible to switch off the return pump when the influence of the delivery volume which is changed due to the pump piston position can be left out of account in the instance the return pump starts to operate.

One embodiment of the present invention is illustrated in the drawings and will be described in detail in the following.

In the drawings,

Figure 1 is a view of the hydraulic circuit diagram of a brake system according to the present invention.

Figure 2 is a wiring scheme relating to the actuation of the valves, comprising the steps introduction, maintaining, and reduction.

The dual-circuit brake pressure transmission device for vehicles, as illustrated in Figure 1, is comprised of a brake cylinder 1 with a brake force booster 2 which is operated by a brake pedal 3. A supply reservoir 4 is arranged at the brake cylinder 1 which contains a pressure fluid volume and is connected to the working chamber of the brake cylinder 1 in the brake release position. The one brake pressure transmission circuit illustrated includes a brake line 5 that is connected to a working chamber of the brake cylinder 1 and has a separating valve 6 which, in its inactive position, provides an open passage for the brake line 5. The separating valve 6 is usually operated electromagnetically. However, variations where a hydraulic actuation is carried out are also feasible.

The brake line 5 branches into two brake pressure lines 8, 9 which lead to a wheel brake 10, 11, respectively. Each of the brake pressure lines 8, 9 contains an electromagnetically operable inlet valve 12, 19 which is open in its inactive position and can be switched to assume a closed position by energization of the actuating magnet. Connected in parallel to each inlet valve 12, 19 is a non-return valve 13 which opens in the direction of the brake cylinder 1. Connected in parallel to these wheel brake circuits 26, 27 is a so-called return delivery circuit which comprises return lines 15, 32, 33 with a return pump 16. By way of one outlet valve 14, 17, respectively, and return lines 32, 33, the wheel brakes 10, 11 are connected to the return line 15 and, hence, to the suction side of the return pump 16 whose pressure side is connected to the brake pressure line 8 in an opening point E between the separating valve 6 and the inlet valves 12, 19.

The return pump 16 is designed as a stroke piston pump with a pressure valve (not shown) and a suction valve. At the suction side of the return pump 16, there is a low-pressure accumulator 20 consisting of a housing 21 with a spring 22 and a piston 23.

A biassed non-return valve 34 which opens towards the return pump is inserted into the connection between the low-pressure accumulator 20 and the return pump.

Further, the suction side of the return pump 16 is connected to the brake cylinder 1 by way of an additional line 30 with a low-pressure damper 18 and a switch valve 31. Besides, the brake force transmission circuit includes a pressure controller 28 with a pressure model 19 for calculating the brake pressure demands in the wheel brake circuits 26, 27. In the pressure controller or in other electronic control units, the wheel brake circuits 26, 27 are evaluated according to the magnitude of the brake pressure demands on the basis of the calculated brake pressure demands in each of the wheel circuits 26, 27. The wheel brake circuits 26 or 27 are divided into a leading or a following wheel brake circuit to such an end that the wheel brake circuit, e.g. 26, with the higher brake pressure demand is determined as the leading wheel brake circuit and that the circuit with the lower brake pressure demand is determined as the following wheel brake circuit 27. In dependence on the steps introduction, maintaining, or reduction of the brake pressures in the wheel brake circuits 26, 27 in a traction slip control operation, controlling or regulating quantities which permit actuating the valves 12, 19, 6, 17, 31 and the return pump are generated based on the brake pressure demands in the pressure controller 28. The following wheel brake circuit 26 or 27 is controlled or regulated by way of the leading wheel brake circuit 26 or 27, that means hydraulic pressure fluid is introduced upon pressure build-up into the following wheel brake circuit with the lower brake pressure demand in the

magnitude of the brake pressure demand from or by way of the leading wheel brake circuit.

As is shown in Figure 2, the pressure build-up in the wheel brake circuits 26, 27 takes place when the switch valve 31 is open and the separating valve 6 closed by way of the actuating signals A and B, with the separating valve 6 being normally open in the initial position and the switch valve 31 being normally closed. In this arrangement, the return pump 16 arranges for the supply of pressure fluid out of the supply reservoir 4 or the low-pressure accumulator 20, by way of the brake cylinder 1, into the wheel brake circuits 26, 27 in which pressure fluid is so introduced in conformity with the calculated brake pressure demand. The pressure fluid is conducted to the wheel brakes 10 and 11 via the opening point E from the brake pressure line 8 of the e.g. leading wheel brake circuit 26 and into the brake pressure line 9 of the following wheel brake circuit 27 by way of the inlet valves 12 and 19. When the calculated value of the brake pressure demand in the following wheel brake circuit 27 is adjusted, the inlet valve 19 is closed by means of a switching pulse. The pressure fluid is introduced by the gradually actuated motor of the return pump in the leading wheel brake circuit 26 until the brake pressure demand is reached. Subsequently, the inlet valve 12 remains open, and the switch valve 31 will be closed. Separating valve 6 remains closed. A constant pressure C develops.

The brake pressure in the wheel brake circuits 26, 27 is maintained preferably when the inlet valve 12 is open. The return pump 16 is operated in a basic load condition, that means with lowest conveying capacity, and/or energy supply, and/or rotational speed so that the pump piston is just about moved by the eccentric. This operation of the return pump 16 in the basic load condition is preferably controlled by way of the

pulse-width modulated actuation of the pump motor when no pressure fluid volume is stored in the low-pressure accumulator 20. In a special case which is not desirable, an excess pressure that is due to the replenishment supply of the return pump out of the low-pressure accumulator 20 or damper 18 during maintaining the brake pressure in the leading wheel brake circuit 26 is effectively prevented by closing of the inlet valve 12. Closing of the inlet valve 12 is effected by a time-responsive switching pulse after closing of the switch valve 31 in driving situations, such as a traction slip control operation on a homogeneous coefficient of friction, in which exceeding of the pressure beyond the value of the brake pressure demand has considerable negative effects on the wheel behavior. Alternatively, the brake pressure as well can be sensed or calculated, and the inlet valve 12 can be closed in response to the brake pressure. The contents of the low-pressure accumulator 20 and/or damper 18 is returned into the brake cylinder 1 and the supply reservoir 4 by way of the pressure-relief valve 25.

The pressure discharge F of the leading wheel brake circuit 26 is effected by opening the separating valve 6 so that pressure fluid flows through the open inlet valve 12, the separating valve 6, and the brake cylinder 1 into the supply reservoir 4. The separating valve 6 is closed by the pressure controller 28 by means of switching pulses D after each pressure reduction. In the following wheel brake circuit 27, pressure fluid is returned out of the wheel brake 11 into the low-pressure accumulator 20 when the outlet valve 17 is open and the inlet valve 19 closed. The low-pressure accumulator 20 assumes a buffer function in this operation.

A correction of the brake pressure demand of the following wheel brake circuit 27 towards a brake pressure increase is carried out by opening the inlet valve 19 out of the leading

wheel brake circuit whose brake pressure demand is also corrected in dependence on predetermined control thresholds or wherein the reduced brake pressure is tolerated.

Patent Claims:

1. Method for the pressure modulation of brake pressures with an electric pressure fluid pump in a dual-circuit brake pressure transmission device, with the steps introduction of a brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, maintaining the brake pressure in the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, and discharge of the brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit,
c h a r a c t e r i z e d in that a split-up of the wheel brake circuits (26, 27) of the one brake pressure transmission circuit into a leading and a following wheel brake circuit with different brake pressure demands is provided, in that the leading wheel brake circuit (26 or 27) is defined as wheel brake circuit with a higher brake pressure demand, and in that the steps introduction, maintaining, and reduction of the brake pressure of the following wheel brake circuit are controlled or regulated by way of the leading wheel brake circuit.

2. Method as claimed in claim 1,
c h a r a c t e r i z e d in that the leading wheel brake circuit (26 or 27) of the wheel brake (10 or 11) is connected to a pressure fluid source (4) by way of opening of a switch valve (31), and the pressure fluid is introduced into the leading and following wheel brake circuits by way of the pressure fluid pump (16) arranged in the wheel brake circuit, with the brake pressure circuit (8, 9) being separated from the pressure fluid source by a separating valve (6).

3. Method as claimed in claim 1 or 2, c h a r a c t e r i z e d in that the leading wheel brake circuit (26 or 27) of the wheel brake is connected to a pressure fluid accumulator (20), with switch valve (31) closed, and the pressure fluid is introduced into the leading and following wheel brake circuits by way of the pressure fluid pump (16) arranged in the wheel brake circuit, with brake pressure circuit (8, 9) being separated from a pressure fluid source (4) by a separating valve (6).

4. Method as claimed in any one of the claims 1 to 3, c h a r a c t e r i z e d in that one inlet valve and one outlet valve (12, 19, 14, 17) is provided in each wheel brake circuit, and the brake pressure demand of the leading and following wheel brake circuits is controlled by way of the inlet valve (19) of the following wheel brake circuit and the pressure fluid supplied by the pressure fluid pump (16) according to the brake pressure demand, with the inlet valve (12) of the leading wheel brake circuit being open, and the outlet valves (14, 17) of the leading and following wheel brake circuit being closed.

5. Method as claimed in any one of claims 1 to 4, c h a r a c t e r i z e d in that the brake pressure demand of the following wheel brake circuit is changed by delivery out of the leading wheel brake circuit, with the inlet valve (12 or 19) of the following wheel brake circuit open and with an active or passive pressure fluid pump.

6. Method as claimed in any one of claims 1 to 5, c h a r a c t e r i z e d in that the brake pressure of the wheel brake circuits is maintained, with the switch

valve, separating valve and outlet valve closed, and the inlet valve (12 or 19) of the leading wheel brake circuit open, and the outlet and inlet valve of the following wheel brake circuit closed.

7. Method as claimed in any one of claims 1 to 6, c h a r a c t e r i z e d in that when the brake pressure introduced is increased compared to the brake pressure demand, the inlet valve of the leading wheel brake circuit is closed in dependence on the brake pressure in the wheel brake circuit, or in dependence on a time constant correlated to a condition variable.

8. Method as claimed in any one of claims 1 to 7, c h a r a c t e r i z e d in that the brake pressure in the leading wheel brake circuit is discharged into the pressure fluid source (4) by way of the brake pressure circuit by opening the separating valve (6), with the switch and outlet valve closed and the inlet valve (12) open.

9. Method as claimed in any one of claims 1 to 8, c h a r a c t e r i z e d in that the brake pressure in the following wheel brake circuit is discharged through a return line (33, 15) into the pressure fluid accumulator (20) by opening the outlet valve (18) when the inlet valve (19) is closed, with the switch valve and/or separating valve in the leading wheel brake circuit being closed or open in dependence on the steps introduction, or maintaining, or reduction of the brake pressures.

10. Method as claimed in any one of claims 1 to 9, c h a r a c t e r i z e d in that the characteristics for the steps introduction, maintaining, and reduction of the

brake pressure are predetermined by a pressure controller (28).

11. Method as claimed in any one of claims 1 to 10, characterized in that the pressure fluid pump (16) is controlled by way of gradual quantities predetermined by the pressure controller during the introduction of the brake pressure into the leading and following wheel brake circuits.

12. Method as claimed in any one of claims 1 to 11, characterized in that the pressure fluid pump (16) is operated during the steps maintaining and reduction of the brake pressures by way of adjusting the energy supply, and/or the rotational speed, and/or the conveying capacity in a predetermined basic (load) condition, preferably with lowest energy supply, rotational speed, and/or conveying capacity.

Abstract:

Method for the Pressure Modulation of Brake Pressures

The present invention relates to a method for the pressure modulation of brake pressures with an electric pressure fluid pump in a dual-circuit brake pressure transmission device, with the steps introduction of a brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, maintaining the brake pressure in the one and/or the other wheel brake circuit of the one brake pressure transmission circuit, and discharge of the brake pressure into the one and/or the other wheel brake circuit of the one brake pressure transmission circuit.

To reduce noise emissions and to enhance the possibilities of braking intervention by the driver during a braking operation by independent force, a split-up of the wheel brake circuits (26, 27) of the one brake pressure transmission circuit into a leading and a following wheel brake circuit with different brake pressure demands is provided, wherein the leading wheel brake circuit (26 or 27) is defined as wheel brake circuit with a higher brake pressure demand, and wherein further the steps introduction, maintaining, and reduction of the brake pressure of the following wheel brake circuit are controlled or regulated by way of the leading wheel brake circuit.

(Figure 1)

Fig. 1

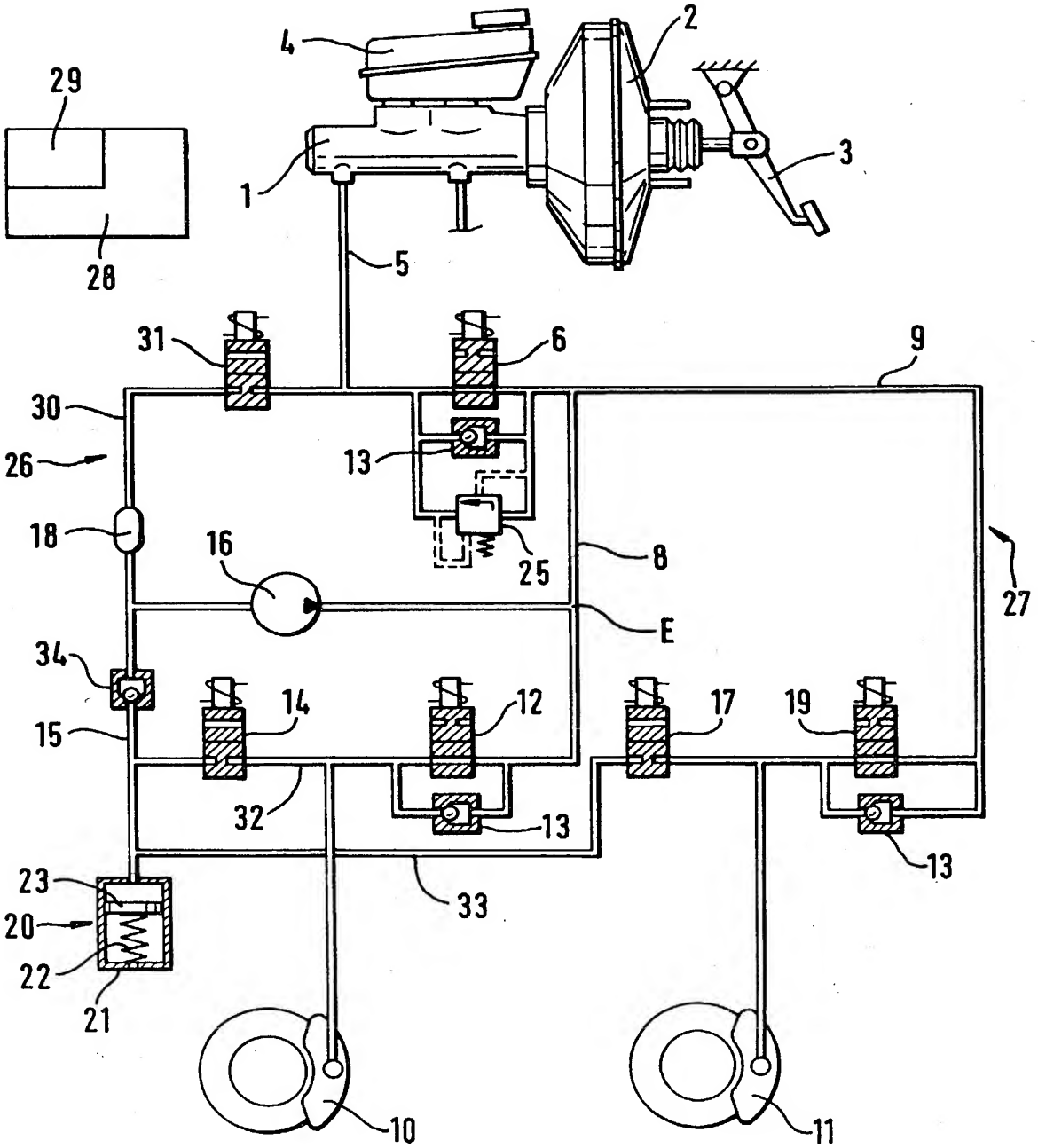
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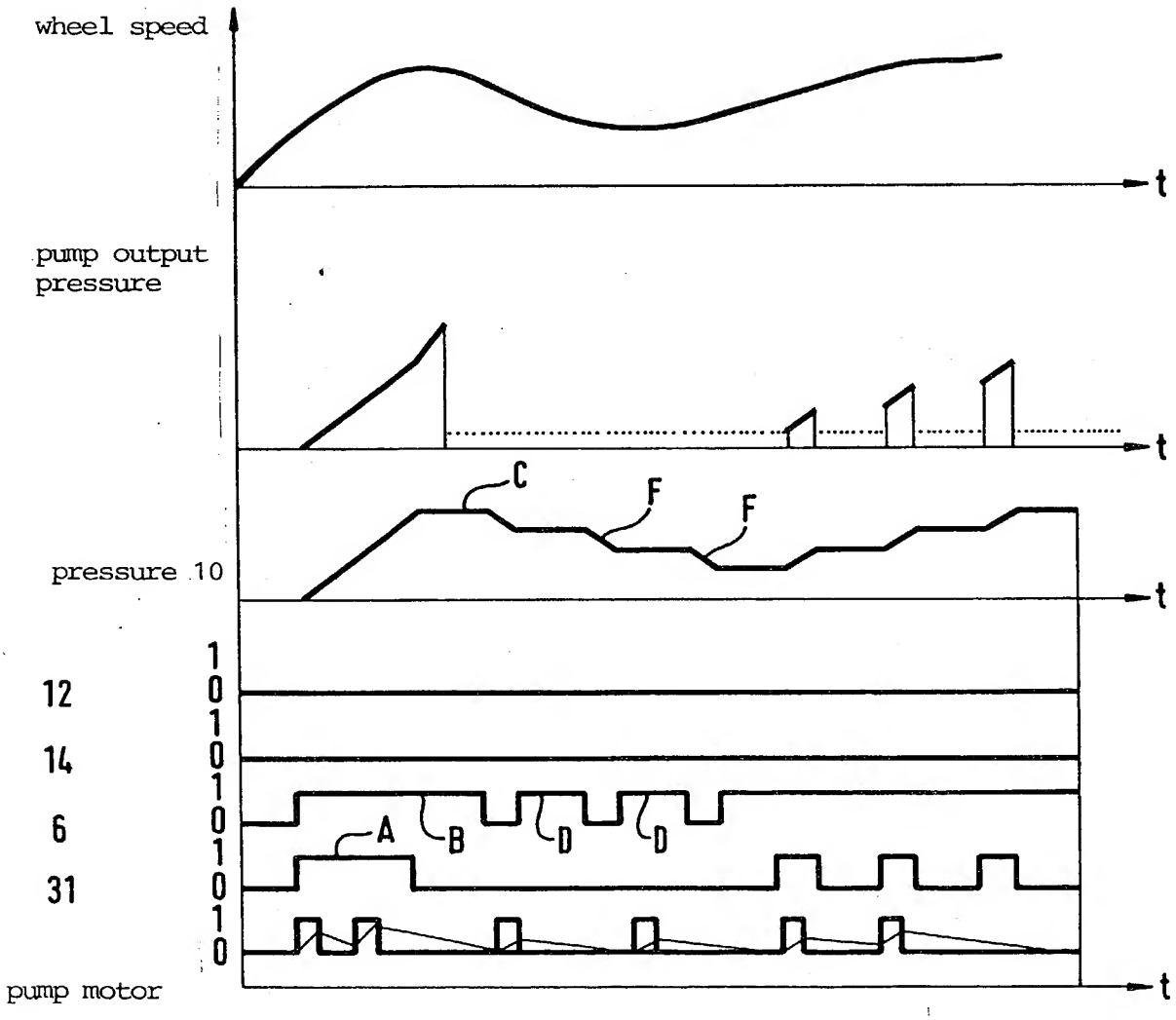
Fig. 2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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD FOR PRESSURE MODULATING BRAKE PRESSURES

the specification of which is attached hereto unless the following box is checked:

was filed on **27/April/2000**
as United States Application Number or PCT International Application Number
PCT/EP00/03785

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above and as amended in a preliminary amendment.

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Prior Foreign Applications (Frühere ausländische Anmeldungen)		Priority Not Claimed Priorität nicht beansprucht
19919841.1	Germany	30/April/1999
Number	Country	Day/Month/Year Filed

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I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s)listed below.

Application No. , filed on

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Ich beanspruche hiermit die mir unter Title 35, US-Code, § 120 zustehenden Vorteile aller unten aufgeführten US-Patentanmeldungen bzw. § 365(c) aller PCT internationalen Anmeldungen, welche die Vereinigten Staaten von Amerika benennen, und erkenne, insofern der Gegenstand eines jeden früheren Anspruchs dieser Patentanmeldung nicht in einer US-Patentanmeldung, bzw. PCT internationalen Anmeldung in in einer gemäß dem ersten Absatz von Title 35, US-Code, § 112 vorgeschriebenen Art und Weise offenbart wurde, meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Title 37, Code of Federal Regulations, § 1.56 von Belang sind und die im Zeitraum zwischen dem Anmeldetag der früheren Patentanmeldung und dem nationalen oder im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesen (PCT) gültigen internationalen Anmeldetags bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

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Ich erkläre hiermit, daß alle in der vorliegenden Erklärung von mir gemachten Angaben nach bestem Wissen und Gewissen der Wahrheit entsprechen, und ferner daß ich diese eidesstattliche Erklärungin Kenntnis dessen ablege, daß wissentlich und vorsätzlich falsche Angaben oder dergleichen gemäß § 1001, Title 18 des US-Code strafbar sind und mit Geldstrafe und/oder Gefängnis bestraft werden können und daß derartige wissentlich und vorsätzlich falsche Angaben die Rechtswirksamkeit der vorliegenden Patentanmeldung oder eines aufgrund deren erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Attorney's Docket No:

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German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den (die) nachstehend aufgeführten Patentanwalt (Patentanwälte) und/oder Vertreter mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Angelegenheiten vor dem US-Patent- und Markenamt:

JOSEPH V. COPPOLA, SR. 33373

CUSTOMER NO. 010291

Korrespondenzadresse:
Joseph V. Coppola, Sr.
Rader, Fishman & Grauer PLLC
Suite 140
39533 Woodward Ave., Suite 140
Bloomfield Hills MI 48304
Telefon: (248) 594-0650

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

JOSEPH V. COPPOLA, SR. 33373

CUSTOMER NO. 010291

Correspondence Address:
Joseph V. Coppola, Sr.
Rader, Fishman & Grauer PLLC
Suite 140
39533 Woodward Ave., Suite 140
Bloomfield Hills MI 48304
Phone No.: (248) 594-0650

FIRST NAMED INVENTOR	SECOND NAMED INVENTOR
1-01 **MICHAEL LATARNIK (deceased-completed on three added page by three joint heirs; Eva-Maria Latarnik, Christine Latarnik, and Sylvia-Monika Latarnik)**	2-00 **JOCHEN FÜHRER**
N/A Signature Date	J. Führer 11 Feb. 2002 Signature Date
POST OFFICE ADDRESS AND RESIDENCE **Römerstraße 7** **D-61381 Friedrichsdorf, Germany** DEX	**POST OFFICE ADDRESS AND RESIDENCE** Gundolfstrasse 24 D-64287 Darmstadt, Germany DEX
Citizen of Germany	**Citizen of Germany**
THIRD NAMED INVENTOR	FOURTH NAMED INVENTOR
3-00 MARKUS BENDER	4-00 **TOBIAS SCHELLER**
X Signature 11 Feb. 2002 Date	X Signature 11 Feb. 2002 Date
POST OFFICE ADDRESS AND RESIDENCE Schelmenweg 39 D-60388 Frankfurt am Main, Germany DEX	**POST OFFICE ADDRESS AND RESIDENCE** Rombergstrasse 12 D-65931 Frankfurt am Main, Germany DEX
Citizen of Germany	**Citizen of** Germany

Practitioner's Docket No. AP9627

ADDED PAGE TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR SIGNATURE BY HEIR (37 C.F.R. § 1.42 AND 1.43)

1-11 I, Christine Latarnik ,
(type or print name(s) of administrator(trix), executor(trix) legal representative or all heirs)

hereby declare that I am a citizen of Germany ,

residing at and having a post office address of Römerstraße 7, D-61381 Friedrichsdorf, Germany DEX .

and that I am executing and signing the declaration to which this is attached as

(check one):

[ ] the administrator(trix) of
[ ] executor(trix) of the last will and testament of
[ ] legal representative (or heirs) of
[ ] heir(s) of
[x] one of three joint heirs of

Michael Latarnik
Full name of (first, second etc.) deceased or incapacitated inventor

Germany
Country of citizenship of deceased or incapacitated inventor

Römerstraße 7, D-61381 Friedrichsdorf, Germany
Residence of deceased or incapacitated inventor
Römerstraße 7, D-61381 Friedrichsdorf, Germany
Post Office Address of deceased or incapacitated inventor

NOTE: The name of the first, second etc. deceased or incapacitated inventor should preferably also be filled in at the appropriate prior space of the declaration adding the words "deceasedeompleted on added page" or "incapacitated-completed on added page."

That, upon information and belief, I aver those facts that the inventor is required to state.

Date: 01. 12. 2001 Christine Latarnik **CHRISTINE LATARNIK** **Heir**

Date: 01. 12. 2001 Sylvia Latarnik **SYLVIA MONIKA LATARNIK** **Heir**

Date: 01.12.01 Evaloria Latarnik **EVA-MARIA LATARNIK** **Heir**

Practitioner's Docket No. AP9627

ADDED PAGE TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR SIGNATURE BY HEIR (37 C.F.R. § 1.42 AND 1.43)

2-11 I, Sylvia Monika Latarnik ,
(type or print name(s) of administrator(trix), executor(trix), legal representative or all heirs)

hereby declare that I am a citizen of Germany ✓ ,

residing at and having a post office address of Römerstraße 7, D-61381 Friedrichsdorf, Germany 2EX

and that I am executing and signing the declaration to which this is attached as

(check one):

[ ] the administrator(trix) of
[ ] executor(trix) of the last will and testament of
[ ] legal representative (or heirs) of
[ ] heir(s) of
[x] one of three joint heirs of

Michael Latarnik
Full name of (first, second etc.) deceased or incapacitated inventor

Germany
Country of citizenship of deceased or incapacitated inventor

Römerstraße 7, D-61381 Friedrichsdorf, Germany
Residence of deceased or incapacitated inventor
Römerstraße 7, D-61381 Friedrichsdorf, Germany
Post Office Address of deceased or incapacitated inventor

NOTE: The name of the first, second etc. deceased or incapacitated inventor should preferably also be filled in at the appropriate prior space of the declaration adding the words "deceased-completed on added page" or "incapacitated-completed on added page."

That, upon information and belief, I aver those facts that the inventor is required to state.

Date: 01.12.2001
Christine Latarnik
CHRISTINE LATARNIK
Heir

Date: 01.12.2001
Sylvia Latarnik
SYLVIA MONIKA LATARNIK ✓
Heir

Date: 01.12.01
Eva-Maria Latarnik
EVA-MARIA LATARNIK
Heir

Practitioner's Docket No. AP9627

ADDED PAGE TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR SIGNATURE BY HEIR (37 C.F.R. § 1.42 AND 1.43)

3-11 I, Eva-Maria Latarnik ,
(type or print name(s) of administrator(trix), executor(trix), legal representative or all heirs)

hereby declare that I am a citizen of Germany ,

residing at and having a post office address of Alexanderstrasse 31/5, 64283 Darmstadt, Germany DEX

and that I am executing and signing the declaration to which this is attached as

(check one):

[ ] the administrator(trix) of
[ ] executor(trix) of the last will and testament of
[ ] legal representative (or heirs) of
[ ] heir(s) of
[x] one of three joint heirs of

Michael Latarnik
Full name of (first, second etc.) deceased or incapacitated inventor

Germany
Country of citizenship of deceased or incapacitated inventor

Römerstraße 7, D-61381 Friedrichsdorf, Germany
Residence of deceased or incapacitated inventor
Römerstraße 7, D-61381 Friedrichsdorf, Germany
Post Office Address of deceased or incapacitated inventor

NOTE: The name of the first, second etc. deceased or incapacitated inventor should preferably also be filled in at the appropriate prior space of the declaration adding the words "deceased-completed on added page" or "incapacitated-completed on added page."

That, upon information and belief, I aver those facts that the inventor is required to state.

Date: 01. 12. 2001
Christine Latarnik **CHRISTINE LATARNIK**
Heir

Date: 01.12.2001
Sylvia Latarnik **SYLVIA MONIKA LATARNIK**
Heir

Date: 01.12.01
Eva-Maria Latarnik **EVA-MARIA LATARNIK**
Heir ✓